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Modeling Firm Competitiveness for Strategy Formulation

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Abstract. This paper presents a process of modeling competitiveness at the firm level for strategy formulation purposes. The modeling process consists of four interactive components: managerial situation, conceptual model, formal model, and strategy. These four components are interacted through four sub-processes named, conceptualization, modeling, obtaining solution, and implementation. Although all the components and sub-processes will be discussed, the emphasis however will be more on managerial situation and conceptual model within the context of firm competition. The industrial competitiveness model developed using the proposed modeling process will be explained and how it can be used in SWOT analysis, building decision support system, marketing strategy, likely market share estimation, and technology selection.

Keywords. Competitiveness, strategy, operational research, conceptualization, modeling, frameworks versus models, potential and actual competitiveness, marketing strategy, technology selection, performance management.

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1. INTRODUCTION

Modeling competitiveness at the firm level for the purpose of strategy formulation or strategy formation is a challenge for the scholars both in strategy area and operational research. Porter (1991) compares and contrasts two basic approaches to strategy that are favored in the literature; namely, framework approach versus model-based approach.

In this paper, we discuss how the two approaches are integrated through a particular modeling process through which "framework", "model", and "strategy" are naturally linked to one another in the oneness of "managerial situation"

The organization of this paper is as follows. Section 2 discuses a particular modeling process for understanding firm competitiveness through "conceptualization", "modeling", "solution", and "implementation" in order to formulate competitive strategy. Section 3 presents a particular "industrial competitiveness model" that is developed for strategy formulation purposes through using that particular modeling process. Section 4 provides some cases where the "industrial competitiveness model" has been used in practice and lists some other potential application areas. Finally, Section 5 includes some concluding remarks about the modeling process and its product, the "industrial competitiveness model."

2. MODELING PROCESS AND COMPETITIVENESS

Managerial situations are getting so complex in nature and so vast in scope, one gets the impression that it is almost impossible to model them properly and in a representative way. This high level of complexity and wide scope of managerial situations seems to have created a continuous debate among the "scientists", who are usually in favor of "models" and "practitioners", who mostly opt for "frameworks". As frequently reported in the operational research literature (Oral and Kettani, 1993), "scientist-strategist" accuses "practitioner-strategist" of not being rigorous and objective enough in constructing their "frameworks" but are in return criticized by "practitioner-strategists" as being increasingly irrelevant to the real world strategic issues while developing their "models". The reader is referred to Porter (1991) for a detailed discussion on the usefulness of "frameworks" and "models" in strategy formulation.

In fact, progress in both "scientific-model" perspective and "practice-framework" perspective are needed in order to improve the methodology of strategy formulation and

contribute to the understanding of real world strategic issues. It is most beneficial if "practitioner-strategists" seek to improve their practice both by drawing on and making full use of seemingly purely scientific work, and also by reviewing and improving their own methods and procedures. By the same argument, "scientist-strategists" should seek to develop and improve their own approaches by being aware of and sensitive to the nature of the needs for dealing with real world strategic issues.

The present paper proposes a way of combining both the "scientist-strategist" approach, by offering a formal model, and the "practitioner-strategist" approach, by constructing a conceptual model or a framework. This is to be achieved using the quartet of "managerial situation", "conceptual model", "formal model", and "strategy", the modeling process suggested by Oral and Kettani (1993), which is depicted in Figure 1.

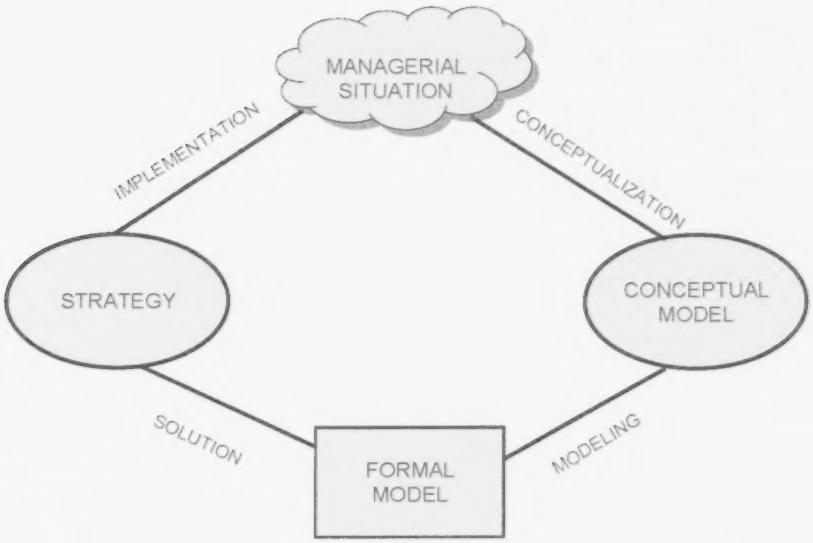

Figure 1: Modeling Process Incorporating Framework and Model

In Figure 1, the four stages of the modeling process (managerial situation, conceptual model, formal model, and strategy) are synergistically integrated into one whole through four connecting sub-processes; namely, "conceptualization", "modeling", "solution", and "implementation". We shall now describe these stages and sub-processes in connection with firm competitiveness.

Managerial Situation: The way the real world events are interpreted by managers or decision-makers leads to a perception of "managerial situation". Any perception that attracts the attention and effort of relevant managers is an issue of "managerial situation". "Managerial situation", a term also used by Beer (1994), perhaps for the first time in the strategy literature, is an abstraction of a certain set of real world events as an attention-allocation device to set up an agenda for future analysis and solution efforts. In a sense, "managerial situation" is a conceptual entity that reflects the ontological assumptions of managers, the perceivers.

"Managerial situation" can present itself in different forms (Oral and Kettani, 1993). It could be a "problem" to be solved or removed, or an "assessment" to position oneself vis-à-vis others, or a "prediction" to foresee likely opportunities and threads ahead, or an "analysis" to better understand the factors governing a system and its environment. Smith (1888, 1989) suggested an heuristic theory of managerial problem definition and structuring, which conceptually corresponds to our "managerial situation" here. In this paper, more specifically, "managerial situation" is to analyze the competitiveness of an industrial firm for the purpose of more effective and better competitive strategy formulation.

Conceptual Model: This term in fact corresponds to "framework" in the strategy literature. As Landry *et al* (1983) stated, a "conceptual model" is a coherent "mental image" of the "managerial situation" and is formed by the prevailing perceptions, value judgments, preferences, experience, and knowledge of both managers and model-builders. A "conceptual model" is expected to indicate, at least in general terms, the angle of attack; goals to be pursued; the factors and variables of the "managerial situation" to be included and to be excluded; the level of aggregation of factors and variables; and perhaps more importantly the relationships between factors and variables; the actual and potential constraints on human, financial, and physical resources; the nature of assumptions made; for whom, by whom, and why it is formulated. In short, a "conceptual model" is an orderly framework for thinking of how the "managerial situation" can be best described. For a more detailed discussion of "conceptual model", the reader is referred to Landry *et al* (1983) and Oral and Kettani (1993).

In this paper, our objective is to offer a "conceptual model" that corresponds to the "managerial situation", which is to "analyze competitiveness of an industrial firm for the purpose of more effective and better competitive strategy formulation", and the constructed "conceptual model" that is eventually leading to development of a "formal model".

Formal Model: Expressing and representing the "conceptual model" in a language of choice (be mathematics, computer codes, spreadsheets, graphs and figures, etc.) leads to development of a "formal model". A "formal model" therefore could be a mathematical, or a statistical, or a computer, or an analogue model, or any combination of these models, as we shall see later. The primary objective of developing a "formal model" is to be able to systematically study the "managerial situation", as represented by the "formal model", in order to better understand it or to obtain solutions, be near-optimal or optimal, for formulating decisions and strategies. Once such a "formal model" is developed representing the "managerial situation" at a satisfactory level, then one can make "experiments" through it about the "managerial situation" to see the likely implications of alternative decisions or strategies.

In this paper, we present an "industrial competitiveness model" that allows to make competitiveness analysis through a pair wise comparison; that is, the firm against the competitor in a given market of interest.

Strategy: Strategy is a decision as to which alternative course of action is to be taken for implementation or which areas are to be given more managerial attention in order to make a considerable change in terms of management style, technology, resource and capability creation, knowledge acquisition and dissemination, marketing activities, and performance improvement. For such strategic decisions to be taken, one needs to know the available strategic alternatives and their possible consequences. These strategic alternatives are expected to be obtained from the "formal model" developed for this purpose. The solution, especially if it is an optimal solution, obtained from the "formal model" could very well be the "strategy" itself. For a more detailed discussion linking solutions to decisions, see Oral and Kettani (1993)

In our managerial situation case, which is "competitiveness analysis for strategy formulation", we shall discuss how the "industrial competitiveness model" presented in this paper can be used to formulate competitive strategies as a function of two types of competitiveness levels: potential competitiveness level and actual competitiveness level.

The four stages of the modeling process; namely, "managerial situation", "conceptual model", "formal model", and "strategy" are linked through four sub-processes. As can be seen from Figure 1, the sub-process "conceptualization" produces a "conceptual model" that corresponds to a "managerial situation". To obtain a "conceptual model" one might repeat or revise the sub-process "conceptualization" several times until a satisfactory one is eventually

constructed. The sub-process "modeling" converts the "conceptual model" into a "formal model" that is sufficiently representative of "the conceptual model" and useful for the purpose it is being developed; namely, formulating competitive strategy. Again as in the case of "conceptualization", the "modeling" sub-process might also require going back and forth several times until a "formal model" is developed which is sufficiently representative of the "conceptual model" and leads to obtaining solutions without much computational difficulties and inefficiencies. The objective of the third sub-process "solution" is to find answers or to obtain solutions from the "formal model" in order to guide or formulate "strategies". The last sub-process "implementation" is to put "strategy" into action and thus addressing the "managerial situation" as it is perceived and reflected in four stages and sub-processes of the modeling process.

The guiding principle in conducting these four sub-processes of the modeling process is that each sub-process should produce a stage that is representative of the previous stage and useful for the coming stages. For instance, the sub-process "conceptualization" should produce a "conceptual model" that is not only representative of the "managerial situation" but also leads to construction of a "formal model" from which obtaining solutions are also computationally or otherwise feasible.

3. AN INDUSTRIAL COMPETITIVENESS MODEL

The subject of competition has been on the academic agenda for a long time and its mathematical foundation goes back to as early as the times of Cournot (1838). It is in fact a subject of interest to many; from politicians to economists, from managers to mathematicians, from researchers to practitioners, and to society at large. This is simply due to the fact that survival of firms and nations is perceived to be a function of their competitiveness levels. In the literature, the subject of competition is treated, broadly speaking, at two levels: firm level and national level. Porter's *Competitive Advantage of Nations* (1990) and the annual reports and yearbooks published by World Economic Forum (WEF) and International Management Development (IMD), both based in Switzerland, are examples of studies dealing with competition at national and industry levels. The firm level studies can also be classified in two groups: those based on frameworks and those on models. For the framework-based studies, we can cite the works of Porter (1980, 1985) as typical examples. The studies of Karnani (1982, 1984) and Oral (1986, 1993) are, on the other hand, examples of a model-based approach to firm competitiveness.

The modeling process presented in this paper tries to maintain the advantages of both framework-based and model-based approaches to competitiveness analysis by constructing a mathematical model based on a framework that conceptualizes firm competition in a larger competitive environment at the national and international levels. In this section, therefore, we shall concentrate on the construction of the "conceptual model" first and then on the "formal model".

First, however, we shall introduce and define a "unit of competitiveness analysis" for strategy formulation at the firm level. To talk about competitiveness at the firm level, we need a "firm" and a "competitor" offering the same group of products and services to meet the expectations of customers in a given "market". As can be observed from Figure 2, the "firm" could be located, although not necessarily, in a environment that is different than that of the "competitor" and the "market". If all three of them are in the same political economic environment, then two local firms are competing against each other in their own domestic market. So there could be four possible combinations for the unit of competitiveness analysis: D-D-D, D-D-F, D-I-D, and D-I-F, where D = Domestic, I = International, and F = Foreign. For instance, D-I-F corresponds to a unit of competitiveness analysis where a **D**omestic firm is competing against a **F**oreign competitor in an **I**nternational market.

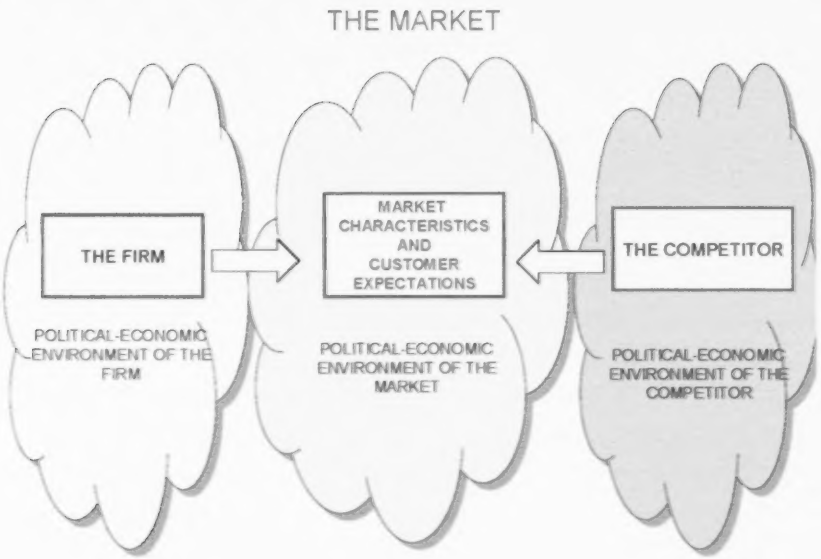

Figure 2. The Unit of Competitiveness Analysis

The unit of competitiveness analysis in Figure 2 necessitates a clear understanding what customer expectations are and how they are relatively met by the firm and the competitor. As a function of market characteristics, customer expectations related to the attributes of products and services such as price, quality, quantity, delivery period, functionality, design, and packaging might vary considerably. However, once a market is chosen for the unit of competitiveness analysis, all these attributes are fixed in the sense that both the firm and the competitor strive to meet the expectations of customers in that market.

Let us assume that the level of customer expectations with respect to the set of customer expectations in the chosen market is denoted by **E**. Both the firm and the competitor would like to meet these expectations. However, they would be able to meet these customer expectations at different levels because of the differences in their technological and managerial characteristics, including their respective political economic environments. Let us assume that E_F as the level of customer expectations met by the firm, and E_C by the competitor. A comparison of E_F and E_C will reveal whether the firm or the competitor is better in meeting the customer expectations **E**.

From the perspective of competitive strategy formulation, finding E_F, E_C, and **E** is not sufficient, because they simply position the firm and the competitor with respect to each other in terms of customer expectations. Although this is nice to know, we in fact need more in order to take measures that will improve the performance of our firm, because the objective is to formulate strategies. This can be done only if we can establish a functional relationship between the technological and managerial characteristics of the firm and its level of customer expectations met. Let us assume that such a functional relationship f is established and we have $E_F = f(C_F)$, where C_F denotes the technological and managerial characteristics of the firm. Then we can look at the difference between E_F and **E** to see how close we are to meeting the expectations of the customers in the chosen market. If we are not satisfied with the level indicated by E_F, when compared with **E**, then we try to make changes in C_F so that E_F and **E** will match as much as possible. This is a way of getting as close as possible to the level of customer expectations, but in isolation from competition. There is also a competitor who is trying to achieve the same thing with a similar set of characteristics, C_C. Therefore, we need not look only at the difference between E_F and **E**, but also at the difference between E_C and **E**. A comparison of the two differences; that is, $(E - E_F)$ versus $(E - E_C)$, might be very useful to position the firm against the competitor in

the market with respect to meeting customer expectations. Alternatively, one can also consider the ratio E_F/E_C, as we shall do soon, to relatively position the firm and the competitor against each other. This observation then allows us to convert Figure 2 into Figure 3 in the following way.

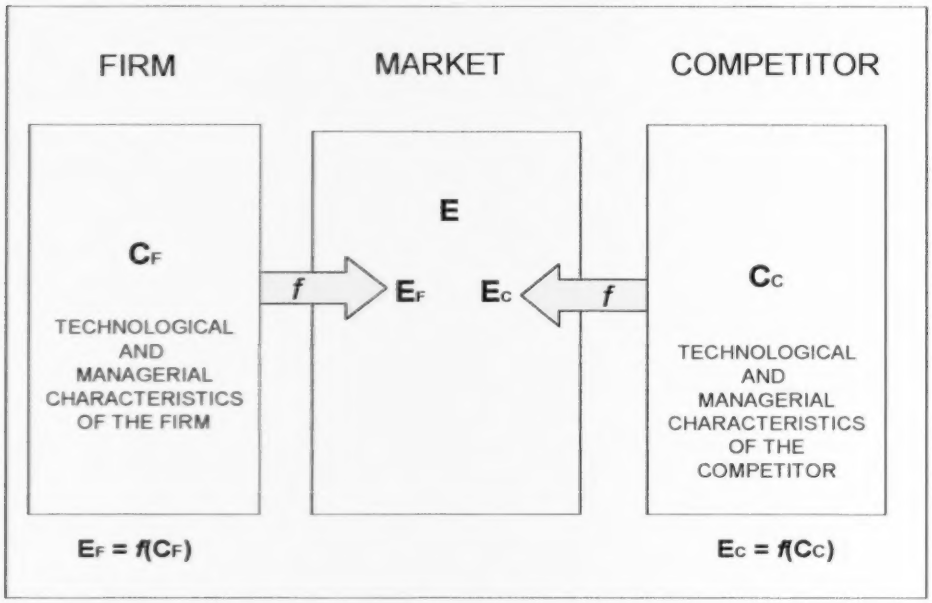

Figure 3: The Unit of Competitiveness Analysis – A More Formal Representation

The more formal unit of competitiveness analysis given in Figure 3 indicates that once we obtain the function f, then it will be sufficient to compare the characteristics of the firm and the competitor to understand to what extent each firm is relatively able to meet customer expectations better. Put differently, the competitiveness analysis of the firm is based on the comparison of the technological and managerial characteristics of the firm with those of the competitor by assuming that the competitiveness level **L** and E_F / E_C imply one another. The important question is here then which technological and managerial characteristics are to be considered and how these characteristics are to be used to construct a model that will indicate the level of competitiveness for the purpose of competitive strategy formulation?

There are dozens of characteristics that govern or determine the competitiveness level of a firm. While identifying such characteristics there are certain points that need to be taken into consideration: (1) they should govern or determine, directly or indirectly, the level of

competitiveness, (2) the possible dynamics and feedbacks between the chosen characteristics and dynamics of feedback system are to be eventually present, in some way, in the conceptual and formal models, and (3) the formal model should lead to formulation of competitive strategies.

Figure 4 is a conceptual model that depicts the relationships between the elements of a certain set of technological and managerial characteristics, both C_F and C_C. An explanation of the conceptual model in Figure 4 is in order now.

The process of conceptualization is an important activity for it produces a "conceptual model" that represents the way the "managerial situation" is perceived by decision makers. In our context, a "conceptual model" is expected to reflect the nature of competition at the firm level.

Before explaining the factors that govern the competition at the firm level, as implied by the conceptual model in Figure 4, there are four features that need to be pointed out. First, both output and input considerations are taken into account. With respect to outputs, "actual" and "potential outputs" as well as "comparative actual" and "comparative potential outputs" are made parts of the conceptual model. The input side feature is represented by "actual" and "potential cost superiorities". Second, the competitive environment of the firm, as well as that of the competitor, is taken as one of the factors governing competitiveness, directly and indirectly through outputs and cost superiorities. Third, causal relationships between the competitive factors and the feedback system (see Figure 8) are present in the conceptualization. Fourth, strategy formulation is made possible by analyzing the difference between actual competitiveness level and potential competitiveness level.

The primary objective of the modeling process presented in this paper is to formulate competitive strategies. According to the "conceptual model" in Figure 4, competitive strategy is guided by analyzing the difference between two types of competitiveness level. As we shall discuss in more detail later, a firm could find itself in eight different strategic states as a function of the difference between actual and potential competitiveness levels. Each strategic state indicates in which direction the important decisions need to be taken and implemented in order to improve the competitiveness level of the firm.

"Actual competitiveness" is an index which typically takes values on greater 1 or smaller than 1, when it is greater than 1 the firm is more competitive than its competitor; otherwise the competitor is better and ahead in competition. The actual competitiveness

index is formulated to measure how good the firm is in terms of providing competitive weapons and advantages and actually utilizing these weapons and advantages when compared with its competitor. Therefore, this index, as its name implies, is based on the actual performance of the firm when compared with that of the competitor. The actual competitiveness level is determined by three factors; namely, "actual industrial mastery", "actual cost superiority", and "political-economic environment."

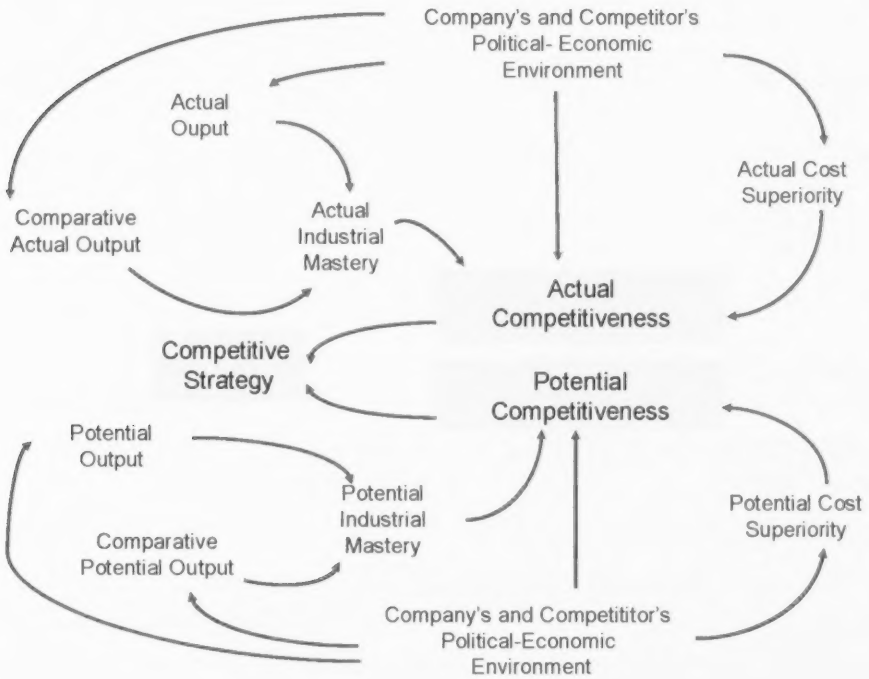

Figure 4: Conceptual Model

"Actual cost superiority" is an index that measures the degree of the advantage the firm possesses against its competitor in terms of actual input prices and actual input usage rates. As we shall see later, the value of the cost superiority index varies around 1. When it is greater than 1 the firm has cost advantage, otherwise the competitor has the upper hand. "Actual Industrial Mastery" is again an index that is formulated to measure the extent to which the firm is actually able to utilize its capital resources and capabilities vis-à-vis the competitor. The actual industrial mastery θ_A, in fact the ratio of "actual output" to "comparative actual output", takes on values around 1; and when it is greater than 1, the firm is superior, otherwise the competitor is better. "Actual competitiveness" level of a firm,

L_A, is determined by both its "actual cost superiority", Π_A, and "actual industrial mastery", θ_A, by using a multiplicative model; that is,

$$L_A = \theta_A \Pi_A . \quad (1)$$

Because the indices θ_A and Π_A take on values around 1, so does the actual competitiveness index L_A. When L_A is greater than 1, the firm is more competitive, otherwise the competitor has the competitive advantage.

It should be noted here that rather than using a *multiplicative* form, one could have used an *additive form* $L_A = \theta_A + \Pi_A$ or the *weakest link of the chain form* as expressed, for instance, in $L_A = \text{Min } \{\theta_A, \Pi_A\}$. The additive form assumes that cost superiority Π_A and industrial mastery θ_A are substitute for one another and the firm might be defined as a competitive one if either Π_A or θ_A is sufficiently high enough to completely substitute for the other, even the other in fact might be almost nil. This is equivalent to saying that a firm might be perfectly competitive even though its cost advantage is zero. Because of this unrealistic implication, the additive form is not a very good representative formulation, for a firm needs to score high enough with respect to both indices to become and stay competitive. Similar arguments can be forwarded in the case of the weakest link of the chain formulation. For a more detailed discussion on this subject the reader is referred to Karnani (1982, 1984).

"Actual output", denoted by Q_F, corresponds to the optimal output produced or being planned by the firm under the prevailing actual conditions. It could be measured in monetary terms or in non-monetary terms, depending on the nature of competition and industry. The concept of "comparative actual output", Q_C, deserves a more careful explanation, for it reflects a comparison of the firm with the competitor in terms of capital resources (machinery and equipment, technical know how, distribution system, etc.) and capabilities. The comparative actual output Q_C is the output that could have optimally produced had the firm possessed the actual technological and managerial characteristics of its competitor. This concept will be clear with the numerical examples that follow.

The lower part of the conceptual model in Figure 4 depicts how the factors of "potential competitiveness" are related to one another. It should be noted that "potential

competitiveness" has the same causal relationships as in the case of "actual competitiveness". More specifically, the "potential competitiveness" level, denoted by L_P, is the product of "potential industrial mastery" θ_P and "potential cost superiority" Π_P: that is,

$$L_P = \theta_P \Pi_P \quad (2)$$

Again as in the case of actual competitiveness, the value of the "potential competitiveness" index also takes on values around 1, since the values of each "potential industrial mastery" θ_P and "potential cost superiority" index Π_P are around 1. Similarly, a value of L_P that is greater than 1 indicates potential competitive superiority of the firm; otherwise the competitor is the superior one of the two.

The nature of the difference between actual and potential competitiveness levels leads to the identification of eight strategic states which the firm could find itself in. The nature of difference is determined by whether (i) the gap between actual and potential competitiveness is significant or not, and (ii) the values of actual and potential competitiveness are greater or smaller than the critical value 1. Each strategic state defined in this manner (see Figure 5) indicates the direction of the decisions to be taken in order to improve the competitive position of the firm. Now we shall briefly discuss these eight strategic states.

Strategic State 1: Good Potential – Moderate Management: This strategic state indicates that the firm is actually competitive (because L_A is greater than 1) and in fact could have done even much better had it utilized its full potential (because L_P is greater than L_A, therefore L_P is much greater than 1). The strategic implication of this state is that the firm must take a set of managerial measures to bring its actual performance to the level indicated by its potentiality. Managerial measures have the priority on the agenda of the firm. There is currently no need for new investments to make its potential higher than what it is now, for they could run the risk of not being fully capitalized in competition.

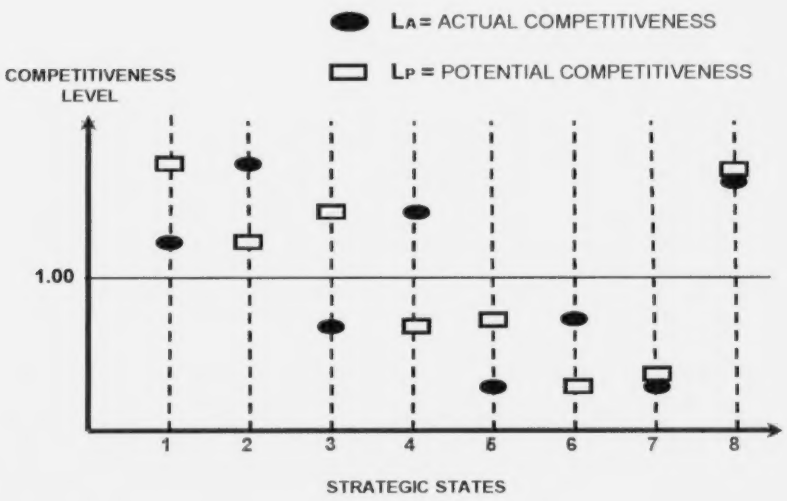

Figure 5: Competitiveness Level and Strategic States

Strategic State 2: Good Management – Moderate Potential: We can claim that the management of the firm is "good" because the actual competitiveness level L_A is much higher than 1, despite of the fact that its potential competitiveness level L_P is smaller than L_A. In other words, although the firm is potentially moderately competitive (because L_P is slightly greater than 1), management is able to realize an actual performance level that is significantly higher than what the moderate potential of the firm indicates. Such a high level of actual performance can be attributed to the relative success of the management team compared with their counterparts in the competitor firm. In such a strategic state, it is most meaningful to make new investments in order to further improve the potentiality of the firm, knowing that it has a good management team and the chances are very high in the sense that the managers can fully utilize new resources and capabilities added to the benefit of the firm.

Strategic State 3: Good Potential – Poor Management: This state indicates that the firm has the potential to compete comfortably (because L_P is sufficiently greater 1), but actually is not able to do so (because L_A is smaller than 1). This situation suggests that there are questions as to the effectiveness of the current management team and therefore some serious managerial measures need to be taken, and rather urgently. New investments

to improve the potential competitiveness can be considered only after managerial measures are put in place and they in fact prove effective.

Strategic State 4: Poor Potential – Good Management: The firm does not have the potential to compete, as indicated by its competitiveness index L_P, having a value quite less than 1. Yet, the firm is actually able to compete successfully, as indicated by its actual competitiveness index L_A, which is significantly greater than 1. This situation is rather risky for the firm since there is always a possibility that the competitor will take necessary measure to activate its own potential against the firm, thus forcing the actual performance to go down to the potential level of the firm, which is currently quite low. This necessitates on the part of the firm to make new investment rather urgently to bring its potential level to somewhere close to its actual competitiveness level. Knowing that the management team is good and actually performing well, the investment plans need be devised and implemented in a relatively short period of time.

Strategic State 5: Poor Potential – Very Poor Management: This strategic state indicates that the firm is in trouble in terms of competition, especially so with respect to actual competitiveness. The firm has already problems when its potential competitiveness level is considered (because L_P is significantly less than 1) and even more so in the case of actual competitiveness level (L_A is not only significantly smaller than 1, but also smaller than the potential level L_P). This situation suggests that the firm is not potentially prepared for competition, indicating a poor potentiality, and at the same time has actually a very poor management performance level since they are far away form even utilizing the potential currently exists in the firm. A two-stage approach is called for here. The first stage needs to deal with the managerial measures in order to improve actual performance level, whereas the second stage should deal with plans of investments to bring the potential competitiveness of the firm to a level that is higher than 1, assuming that managerial measures taken in stage one will justify such new investments.

Strategic State 6: Very Poor Potential – Moderate Management: This strategic state indicates that the firm is really very poor in terms of potential competitive weapons it possesses compared with those of the competitor (because L_P is much smaller than 1). Moreover its actual performance, although higher than the level that is indicated by its potential, is also not very competitive (because L_A is smaller than 1.) This is a problematic situation if new investments cannot be made urgently in order to bring the potential competitiveness level to a point that corresponds at least to its actual performance level.

Again we are facing a two-stage approach in this state too. First, new investments are most urgently required to improve the potential of the firm to an acceptable level, and then a series of management development plans are to be put in place to fully activate the potential generated by the new investments.

Strategic State 7: Very Poor Potential – Very Poor Management: This is the most problematic one of the eight strategic states identified. Both the potential and actual competitiveness levels are very low (both L_A and L_P are much smaller than 1) and very close to one another (the difference between L_A and L_P is almost 0.) The meaning of this is simply that the firm is not competitive at all, neither potentially nor actually. In this case there are two basic options for the firm to take: (1) get out of that business soon, or (2) make urgent investment to increase the potentiality of the firm considerably, and also at the same time, take managerial measures to improve the efficiency and effectiveness of management.

Strategic State 8: Good Potential – Good Management: This is the strategic state in which every firm would like to be and should aim to be. There is no problem at all with respect to competition, be actual or potential (because both L_A and L_P are comfortably higher than 1, and almost equal). The management of the firm is able to fully utilize the high potential provided to their disposal. This state is an enviable position for any firm to be in and the objective is to stay in that state as long as possible.

Having identified strategic states as discussed above is of course useful for guiding competitive decisions, albeit in very general terms, leading to better performance. For instance, statements like "some managerial measures need to be taken urgently" and "investments are urgently to be made" are managerial guidelines and such statements are helpful, but they are too general to become really operational. We need more operational and specific guidelines. However, if one wishes to be more specific and operational about the possible implications of these eight strategic states for strategy formulation then there is a need for a formal model that can provide more detailed and specific information. This is our next task - to suggest a formal model based on the conceptual model previously developed.

The conceptual model depicted in Figure 4 necessitates the development of four sub-models and the formulations of six indices; namely,

- Actual Output Sub-Model
- Comparative Actual Sub-Model
- Potential Sub-Model
- Comparative Potential Sub-Model
- Actual Mastery Index
- Actual Cost Superiority Index
- Potential Industrial Mastery Index
- Potential Cost Superiority Index
- Actual Competitiveness Index
- Potential Competitiveness Index

We shall now present how these sub-models and indices are formulated and show the way they are related to one another.

Actual Output Sub-Model: This is the optimal output the firm is able to produce and sell under the current prevailing conditions. The currently prevailing conditions refer to actual technological and managerial characteristics of the firm, the goals and objectives presently being pursued, market conditions and customer expectations, the constraints imposed by the firm's production and distribution system in terms of capacity limitations, and the like. It is possible to suggest different optimization models that will sufficiently represent the actual output of a firm. We opt for a linear programming model (LPM) for at least three reasons: (1) LPM is widely known and used in practice by many firms around the world for production and distribution planning purposes, (2) LPM results are easy to interpret and useful in decision making, especially through sensitivity analysis, and (3) LPM based competitiveness model presented in this paper has actually been implemented in more than 30 Turkish manufacturing companies (Oral and Ozkan, 1986), thus empirically indicating its value and usability in practice.

The actual output of the firm Q_F can be obtained from the actual output sub-model below:

Actual Output Sub-Model

$$Q_F = Max \sum_j \alpha_j x_j$$

subject to:

$$\sum_j a_{ij} x_j \le A_i, i = 1,2,...,m$$

$$x_j \ge 0, j = 1,2,...,n$$

where x_j = the actually planned quantity of Product *j* per planning period,

α_j = the coefficient that converts the unit of Product *j* into a "standard" unit of output,

a_{ij} = the actual usage rate of capital resource *i* to produce one unit of Product *j*,

A_i = the actual availability level of capital resource *i*.

It is important to attach a managerial meaning to this seemingly standard Actual Output Sub-Model from the perspective of competitiveness analysis. The Actual Output Sub-Model above represents at least the following: (1) The optimal value of the objective function, Q_F, reflects the maximum output the firm is able to produce under the current prevailing conditions; (2) the conversion coefficients, α_j's, account for attributes such as quality, firm image, marketing effectiveness; (3) the actual usage rates of capital resources, a_{ij}'s, correspond to the technological characteristics of the firm; and (4) the availability of capital resources, A_i's, are indicators of how intensively (1 shift versus 3 shifts a day, for instance) the capital resources are used in the firm. A numerical example will help to clarify the concepts better. For this purpose, consider the small example given in the upper-left box in Figure 6.

The numerical example above implies that the firm is making four types of products using five departments, A, B, C, D, and E, which are the capital resources of the firm. Department A is used to make Product 1 and Product 2, whereas Department B is needed to make Product 3 and Product 4. The constrained imposed by the first capital resource, Department A, is that we actually have an availability level of only 8 units per the planning period, the period for which we intend to make competitiveness analysis. For Department B, this availability level is 16 units, and so on. Regarding the technological parameters, for instance Department C, it requires 2 units of capital resource available in Department C to make one unit of Product 1, 3 units to make one unit of Product 2, and 1 unit to make one

unit of Product 3. In a sense the coefficients $a_{31} = 2$, $a_{32} = 3$, and $a_{33} = 1$ in the third constraints are the actual technological parameters of Department C, which correspond to the values a_{ij} 's in the general formulation of Actual Output Model. Similar arguments and explanations also apply to the other constraints in the numerical model. The coefficients in the objective function, on the other hand, indicate how the firm's products are actually valued by its costumers in the chosen market. For instance, the coefficient of x_1 is 20 and it indicates the degree of value or importance attached to Product 1 by customers. The coefficients of x_j 's could be price, unit profit, or in fact any other value reflecting the attributes of customers such as quality, image, etc.

From the numerical sub-model above we find the value of the actual output as $\mathbf{Q_F}$ = \$352, since the optimal solution obtained is $x_1^o = 4, x_2^o = 2, x_3^o = 0, x_4^o = 16$.

Comparative Actual Output Sub-Model: The objective of this sub-model is to be able to compare the firm's actual output performance with that of the competitor. For this purpose, it assumed that the actual technological and managerial capabilities of the competitor apply to the case of the firm. The question then becomes what could have been the optimal output of the firm had it the characteristics of the competitor. For instance, suppose that the competitor has an actual labor productivity of 2 tons of certain output per worker per month. Had the firm the same actual labor productivity, what could have been the actual output with its 300 workers? The answer is 600 tons per month. Then one can assume this amount of output as the comparative actual output, $\mathbf{Q_C}$ = 600, estimated in a pragmatic manner. Rather than relying only on labor productivity, we can expand this concept to include all factors or characteristics of production to the formulation of a measure that reflects the entirety of managerial and technological characteristic of the competitor when applied to the firm. Such a sub-model can be of the form

Comparative Actual Output Sub-Model

$$\mathbf{Q_C} = Max \sum_j \beta_j y_j$$

subject to:

$$\sum_j b_{ij} y_j \le A_i, i = 1,2,...,m$$

$$y_j \ge 0, j = 1,2,...,n$$

where y_j = the quantity of Product *j* that could have been produced per planning period, had the firm possessed the actual technological and managerial parameters of the competitor,

β_j = the competitor's actual coefficient (price, unit profit, or any other monetary or non monetary factor) that converts the unit of Product *j* into a "standard" unit of output,

b_{ij} = the competitor's actual usage rate of capital resource *i* (machinery and equipment, plant space, etc.) to produce one unit of Product *j*.

Some observations need to be made about the two sub-models presented above: (1) Both sub-models have exactly the same structure, except the values of the parameters. For instance, α_j's in the actual output sub-model are replaced by β_j's in the comparative actual sub-model, and a_{ij}'s by b_{ij}'s. (2) The availability levels of capital resources A_i's are maintained at the same level in both sub-models. The reason for doing this "normalization" is to make the comparison meaningful in the context of competitiveness analysis. Through such a normalization method, in fact scaling up or down compared to the size of the firm, we are able to compare a large company with a small company from the perspective of competition. Otherwise, the comparison of the actual outputs of two firms having a large difference in their outputs might be in fact meaningless.

The concept of comparative actual output is important for competitive strategy formulation since it forces the firm's managers to constantly think about and consider the competitor's characteristics. In other words, the *competitive environment* of the firm is partially incorporated through the construction of comparative actual output sub-model, thus methodically contemplating on the competitor as well, a feature that is most essential in formulating competitive strategies.

Again a numerical example will help to clarify the concept behind the comparative actual sub-model. Consider the following example, which is based on the previous numerical example because of the very nature of the comparative actual output sub-model:

Comparing these two numerical sub-models (see the boxes on the left in Figure 6) reveals some insights as to how different the firm is from its competitor. The coefficient in the objective functions indicate that the competitor is in a better position with respect to unit profits of Product 1 (α_1 = \$20 for the firm versus β_1 = \$24 for the competitor) and Product 2 (α_2 = \$8 for the firm versus β_2 = \$12 for the competitor), whereas in the cases of Product 3

and Product 4 both the firm and the competitor are able realize the same unit profits ($\alpha_3 = \beta_3 =$ \$24 for Product 3 and $\alpha_4 = \beta_4 =$ \$16 for Product 4.) Similar observations can be made with respect to technological parameters a_{ij}'s and b_{ij}'s. For instance, the firm's Department A has a better technology to make Product 2 compared with that of the competitor (because $a_{12} = 2 > b_{12} = 3$, implying that the firm has a facility allowing a relatively faster operation) but on the other hand the competitor's facility is better to make Product 1 (because $a_{11} = 1 > b_{11} = 0.5$, implying that the firm's technology is less appropriate to make Product 1.) Comparing each pair this way one can reach conclusions as to who is better, technology wise, on a product basis. The overall advantage or disadvantage is given by the ratio $\mathbf{Q_F/Q_C}$, which is called "actual industrial mastery" θ_A, and its more detailed interpretation will be given soon.

The value of $\mathbf{Q_C}$ = \$ 288, since the optimal solution is $y_1^o = 0, y_2^o = 0, y_3^o = 8, y_4^o = 6$. This value will be used to estimate the actual industrial mastery index shortly.

Potential Output Sub- Model: It is of great importance to know the maximum output that could have been produced if the currently existing potentiality of the firm were fully, most effectively, and efficiently utilized. This sub-model creates awareness, when compared with actual output, about the extent to which the potentiality is currently being successfully used. This kind of awareness is most useful while making operational and investment decisions. Therefore, making use of the potential output sub-model forces managers to constantly think of their potential resources and capabilities that exist and how they are actually being used, and to what extent.

The potential output of the firm $\mathbf{V_F}$, in a sense, is the maximum amount that could be produced with the competitive weapons provided by the executive management of the firm and it can be obtained from a model of the form:

Potential Output Sub-Model

$$\mathbf{V_F} = Max \sum_j \lambda_j u_j$$

subject to:

$$\sum_j c_{ij} u_j \le B_i, i = 1,2,...,m$$

$$u_j \ge 0, j = 1,2,...,n$$

where u_j = the quantity of Product *j* that could have been produced per planning period, had the firm were capable of fully utilizing its existing potential,

λ_j = the coefficient that converts the unit of Product *j* into a "standard" unit of output under the existing potentiality conditions,

c_{ij} = the best usage rate of capital resource *i* to produce one unit of Product *j*, under the existing potentiality conditions

B_i = the availability level of capital resource *i* under the existing potentiality conditions.

There are three observations to be made with respect to actual output sub-model and potential output sub-model: (1) because the objective functions in both sub-models are expressed as "maximization", the coefficients α_j's and λ_j's must comply with the conditions that $\alpha_j \le \lambda_j, \forall j$, implying potential contributions must be at least at the level of actual contributions, which conform to the concept of potentiality. (2) The technological parameters or capital resource usage rates, a_{ij}'s and c_{ij}'s, on the other hand, must comply with the requirements that $a_{ij} \ge c_{ij}, \forall i, j$. (3) The availability levels of capital resources A_i's and B_i's have the relationship $A_i \le B_i, \forall i$, due to the assumption that a firm could potentially have more of capital resources.

Again a numerical example will help to clarify the concept behind the potential output sub-model. Consider the example given at the top right corner in Figure 6, which is based on the previous numerical example of the actual output sub-model.

The value of potential output is found to be as $\mathbf{V_F}$ = \$464, since the optimal solution obtained from the numerical sub-model above is $u_1^o = 4, u_2^o = 0, u_3^o = 0, u_4^o = 24$.

Comparative Potential Output Sub-Model: The comparative potential output is the maximum amount that could have been produced by the firm had it the potentiality of the competitor, that is, the best possible technological and managerial capabilities of the competitor. This sub-model serves the purpose of analyzing what the competitor's executives have achieved in terms of creating competitive weapons against the firm and then anticipating their possible consequences. As in the case of "comparative actual output", this sub-model is also instrumental in creating a systematic awareness about the

potential capabilities of the competitor since it forces the firm's manager to find out how the competitor has prepared itself for competition. The estimate of comparative potential output can be obtained from a model of the form:

Comparative Potential Output Sub-Model:

$$\mathbf{V_C} = Max \sum_j \delta_j v_j$$

subject to:

$$\sum_j d_{ij} v_j \le B_i, i = 1,2,...,m$$

$$v_j \ge 0, j = 1,2,...,n$$

where v_j = the quantity of Product *j* that could have been produced per planning period, had the firm possessed the potential characteristics of the competitor,

δ_j = the coefficient that converts the unit of Product *j* into a "standard" unit of output under the existing potential characteristics of the competitor,

d_{ij} = the best usage rate of capital resource *i* to produce one unit of Product *j*, under the existing potential characteristics of the competitor,

Again a numerical example will help to clarify the concept behind the comparative potential output sub-model. Consider the example given in the bottom right corner box in Figure 6, which is based on the previous numerical example of the potential output sub-model.

The value of comparative potential output is found to be as $\mathbf{V_C}$ = \$640, since the optimal solution from the numerical sub-model above is. $v_1^o = 16, v_2^o = 0, v_3^o = 0, v_4^o = 16$.

Actual Industrial Mastery Index: This index is defined as one of the two major components of "actual industrial competitiveness index" and measures the management performance of the firm in all functional areas such as production, marketing, finance, human resources, etc. It indicates where the firm's actual achievement stands in comparison to that of the competitor with respect to the utilizations of the existing capital resources and capabilities, including know-how. This actual industrial mastery index is defined as:

Actual Industrial Mastery Index

$$\theta_A = \mathbf{Q_F}/\mathbf{Q_C}$$

where θ_A = the actual industrial mastery, Q_F = the actual output, and Q_C= the comparative actual output. In the case of our numerical example, we have

$$\theta_A = Q_F/Q_C = 352/288 = 1.22,$$

a value that indicates the firm's superiority (since it is greater than 1) with respect to actual output because of its relative technological and managerial effectiveness over the competitor against which the comparison is being made.

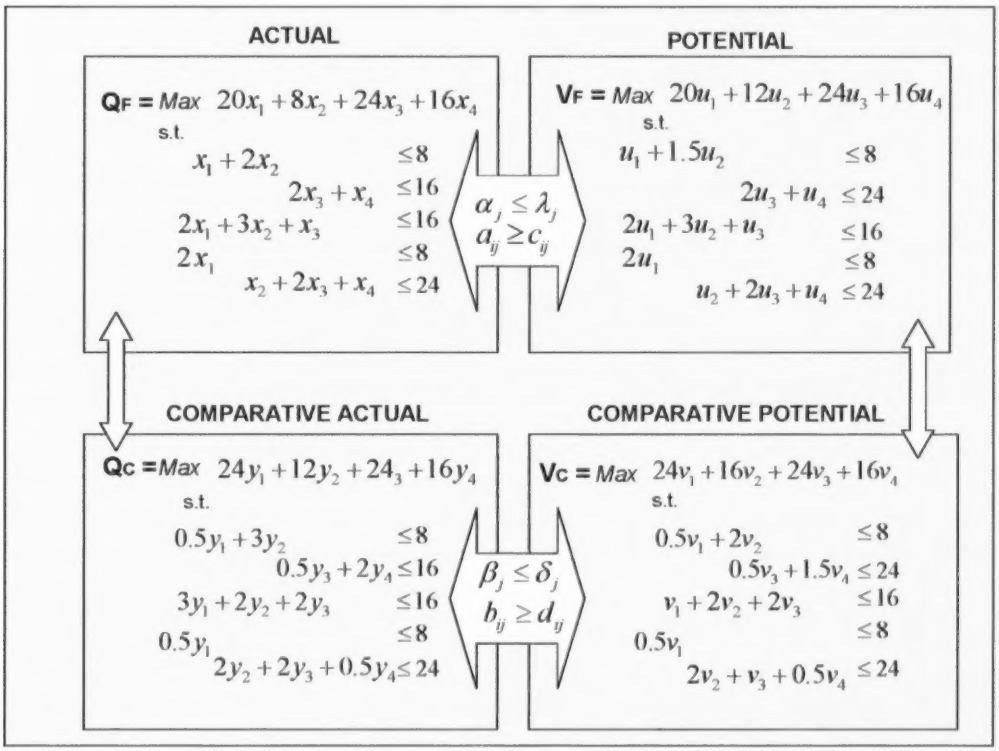
ACTUAL
POTENTIAL
$Q_F = Max\ 20x_1 + 8x_2 + 24x_3 + 16x_4$
s.t.
$x_1 + 2x_2 \le 8$
$2x_3 + x_4 \le 16$
$2x_1 + 3x_2 + x_3 \le 16$
$2x_1 \le 8$
$x_2 + 2x_3 + x_4 \le 24$
$V_F = Max\ 20u_1 + 12u_2 + 24u_3 + 16u_4$
s.t.
$u_1 + 1.5u_2 \le 8$
$2u_3 + u_4 \le 24$
$2u_1 + 3u_2 + u_3 \le 16$
$2u_1 \le 8$
$u_2 + 2u_3 + u_4 \le 24$
$\alpha_j \le \lambda_j$
$a_{ij} \ge c_{ij}$
COMPARATIVE ACTUAL
COMPARATIVE POTENTIAL
$Q_C = Max\ 24y_1 + 12y_2 + 24_3 + 16y_4$
s.t.
$0.5y_1 + 3y_2 \le 8$
$0.5y_3 + 2y_4 \le 16$
$3y_1 + 2y_2 + 2y_3 \le 16$
$0.5y_1 \le 8$
$2y_2 + 2y_3 + 0.5y_4 \le 24$
$V_C = Max\ 24v_1 + 16v_2 + 24v_3 + 16v_4$
s.t.
$0.5v_1 + 2v_2 \le 8$
$0.5v_3 + 1.5v_4 \le 24$
$v_1 + 2v_2 + 2v_3 \le 16$
$0.5v_1 \le 8$
$2v_2 + v_3 + 0.5v_4 \le 24$
$\beta_j \le \delta_j$
$b_{ij} \ge d_{ij}$

Figure 6: Comparing Numerical Sub-Models of Output

Potential Industrial Mastery Index: This is an index that partially measures the firm's top management performance in providing and deploying assets making the firm potentially competitive against the competitor and it is defined as a major component of the potential competitiveness index. The potential industrial mastery index is defined as

Potential Industrial Mastery Index

$$\theta_P = V_F / V_C$$

where θ_P = the potential industrial mastery, V_F = the potential output, and V_C = the comparative potential output. In the case of our numerical example, we have

$$\theta_P = V_F / V_C = 464/640 = 0.73$$

a value that indicates the competitor's superiority with respect to potential output because of its relative technological and managerial effectiveness over the firm. This means that the competitor has really technological and managerial potential to comfortably compete against the firm.

The two indices formulated above, θ_A and θ_P, are indicators that position the firm vis-á-vis the competitor with respect to actual and potential outputs. The production and distribution systems also need, in addition to capital resources, inputs like raw materials, labor, energy, working capital, etc to function. The costs of these inputs and their usage rates considerably shape, especially in price dominant markets, the competitiveness of the firm. To integrate this feature of competition into the industrial competitiveness model two input-related indices are formulated, called "actual cost superiority" and "potential cost superiority, to match the two types of output sub-models.

Actual Cost Superiority Index: This index indicates to what extent the firm has comparative advantage over the competitor with respect to unit costs of input and their usage rates. It embodies two types of comparison. First, it compares the unit costs of inputs. Suppose P_{kR} and P_{kF} are the unit costs of input *k* to the competitor and the firm, respectively. The ratio P_{kr} / P_{kF} is an indicator of whether the firm has a purchasing cost advantage or not against the competitor in the case of input *k*. And also let q_{kF} and q_{kR} be the actual usage rates of input *k* by the firm and the competitor, respectively, to produce one unit of output. Again the ratio q_{kF} / q_{kR} indicates whether the firm has an input usage rate advantage in the case of input *k*. What we need in fact is a formulation that will reflect both unit costs and usage rates for all inputs. Such a formulation could be of the following form:

$$\pi_A = \sum_k \frac{P_{kR}}{P_{kF}\left(q_{kF} / q_{kR}\right)} \omega_{kF} \qquad (3)$$

where ω_{kF} is the "importance" factor of input *k* to the firm. Let us define "the unit cost-to-compete" of the firm as $\sum_k P_{kF} q_{kF}$. If we assume that the "importance" of the input *k* is given by its share in the unit-cost-to-compete; that is,

$$\omega_{kF} = \frac{P_{kF} q_{kF}}{\sum_k P_{kF} q_{kF}},$$

then the actual cost superiority formulation in (3) becomes

$$\Pi_A = \frac{\sum_k P_{kR} q_{kR}}{\sum_k P_{kF} q_{kF}} \tag{4}$$

which is basically the ratio of the unit-cost-to-compete of the competitor over that of the firm. With this definition of actual cost superiority index, the value of Π_A will vary around 1. Any value of Π_A greater than 1 indicates that the firm is in a better position with respect to input costs and usage rates. Otherwise, the competitor has the input cost advantage.

To continue with our numerical example, let us assume that the cost superiority data are as given in Table 1. Then using the formulation given in (4), we obtain the value of the actual cost superiority for Product 1 as $\Pi_A = 0.98$, indicating that the competitor is slightly better than the firm. This is the actual cost superiority for Product 1 only. Since we have three more products to consider, we need to repeat the same procedure for the other three and then combine the values that will represent the overall situation of the firm.

Table 1: Cost Superiority Data for Product 1 – Numerical Example

INPUTS	FIRM ACTUAL		COMPETITOR ACTUAL		FIRM POTENTIAL		COMPETITOR POTENTIAL	
	Unit Cost	Usage Rate	Unit Cost	Usage Rate	Unit Cost	Usage Rate	Unit Cost	Usage Rate
Labor	$20,00	4	$25,00	3	$20,00	3	$25,00	2
Material	$10,00	7	$8,00	8	$9,50	6	$7,75	6
Energy	$5,00	2	$5,50	3	$4,75	2	$5,00	3
Logistics	$2,00	1	$1,50	1	$2,00	1	$1,50	1
Marketing	$1,00	1	$2,00	1	$1,00	1	$2,00	1

Let Π_{Aj} be the actual cost superiority of Product *j* and assume that its relative importance to the firm is given by Q_{Fj}/Q_F, where Q_{Fj} is the value added by Product *j* to the total actual output Q_F. Then the actual cost superiority is given by

$$\Pi_A = \sum_j \Pi_{Aj} \left(Q_{Rj} / Q_{Fj} \right) \quad (5)$$

Using the formula in (4) for each of the four products we obtain the values in Table 2. The first value in the last column in Table 2 is the actual cost superiority that is calculated using the formula in (5). Thus, $\Pi_A = 0.94$. The interpretation of this value is that the firm is as almost as cost effective as the competitor, but not quite so, because it is less than 1.

Table 2: Actual and Potential Cost Superiorities for All Products Combined

	Product 1	Product 2	Product 3	Product 4	Overall
Actual Cost	0,98	0,62	0,64	0,95	0,94
Potential Cost	0,89	0,69	0,86	0,89	0,89
Actual Share	0,23	0,05	0,00	0,73	
Potential Share	0,17	0,00	0,00	0,83	

Potential Cost Superiority Index: This index is useful to analyze and estimate the firm's potential advantage against the competitor with respect to input costs and input usage rates. As the name implies, the objective here is to become aware of the potential that exists in the firm compared with that of the competitor. For instance, the firm might be currently paying certain prices for its inputs; but the purchasing effectiveness could have been perhaps improved by developing better working partnerships with the suppliers, such as through possible quantity discounts, advanced planning for procurements, etc.

Let P^*_{kR} and P^*_{kF} be the potential unit cost of input *k* to the competitor and the firm, respectively. Like in the case of the actual cost superiority, the ratio P^*_{kR} / P^*_{kF} indicates the degree of unit cost advantage the firm potentially has. Also let q^*_{kF} and q^*_{kR} be the potential usage rates of input *k* by the firm and the competitor, respectively, to produce one unit of output. Again, the ratio q^*_{kF} / q^*_{kR} indicates whether the firm has potentially an input usage rate advantage or not in the case of input *k*. What we need now is a formulation that will reflect both unit costs and usage rates for all inputs and such a formulation could be:

$$\Pi_P = \frac{\sum_k P^*_{kR} q^*_{kR}}{\sum_k P^*_{kF} q^*_{kF}} \quad (6)$$

which is equivalent to the formulation in (4), but for the potential cost superiority this time.

Returning to our numerical example again, using the formula in (6) for each product we obtain the values in the second row in Table 2. The second value in the last column in Table 2 is the potential cost superiority, which is, $\Pi_P = 0.89$. The interpretation of this value is that the firm is potentially less cost effective because it is smaller than both 1 and the actual cost superiority $\Pi_A = 0.94$.

With all these formulations, sub-models, and background, we are now ready to give the formulas for both actual and potential competitiveness levels as:

Actual Competitiveness: The actual competitiveness level of the firm against its competitor is given by

$$L_A = \theta_A \Pi_A \qquad (1)$$

Referring to our numerical example, the actual competitiveness of the firm is

$$L_A = \theta_A \Pi_A = (1.22)(0.94) = 1.15.$$

This value of $L_A = 1.15$ indicates that the firm is actually able to compete, because it is greater than 1. But this is not a very comfortable position to be in since the value of L_A is not sufficiently greater than 1. This piece of information alone is not sufficient to formulate competitive strategies, for we need also information about our potential competitiveness to understand better the situation we are in.

Potential Competitiveness Levels: The potential competitiveness of the firm against its competitor is given by

$$L_P = \theta_P \Pi_P \qquad (2)$$

In the case of our numerical example, the potential competitiveness of the firm is

$$L_P = \theta_P \Pi_P = (0.73)(0.89) = 0.65.$$

This value of $L_P = 0.65$ is hardly encouraging since it indicates that the firm is potentially in a very weak position, because it is considerably below 1. In other words, when the potential performances are considered, the competitor is in a much better position, meaning that the competitor has provided advantageous competitive weapons in terms of technological parameters compared with the firm. The firm is not expected to be able to compete in the long run!

It is interesting to observe that the actual competiveness level is in fact higher than the potential competitiveness level, because $L_A = 1.15 > L_P = 0.65$, indicating that the firm is in strategic State 4 shown in Figure 5: Poor Potential – Good Management. Although the firm is not well equipped to compete potentially, but somehow it is actually able to do so. This situation implies that the firm has a very good management team and/or the competitor currently has problems activating their resources and capabilities to their advantage. Strategic implication of this state is that the firm needs to make investments to increase its potential to a level higher than 1. But in which areas? This will be discussed in the next section, since the measures to be taken will depend very much on the details of the industrial competitiveness model that will be put in use.

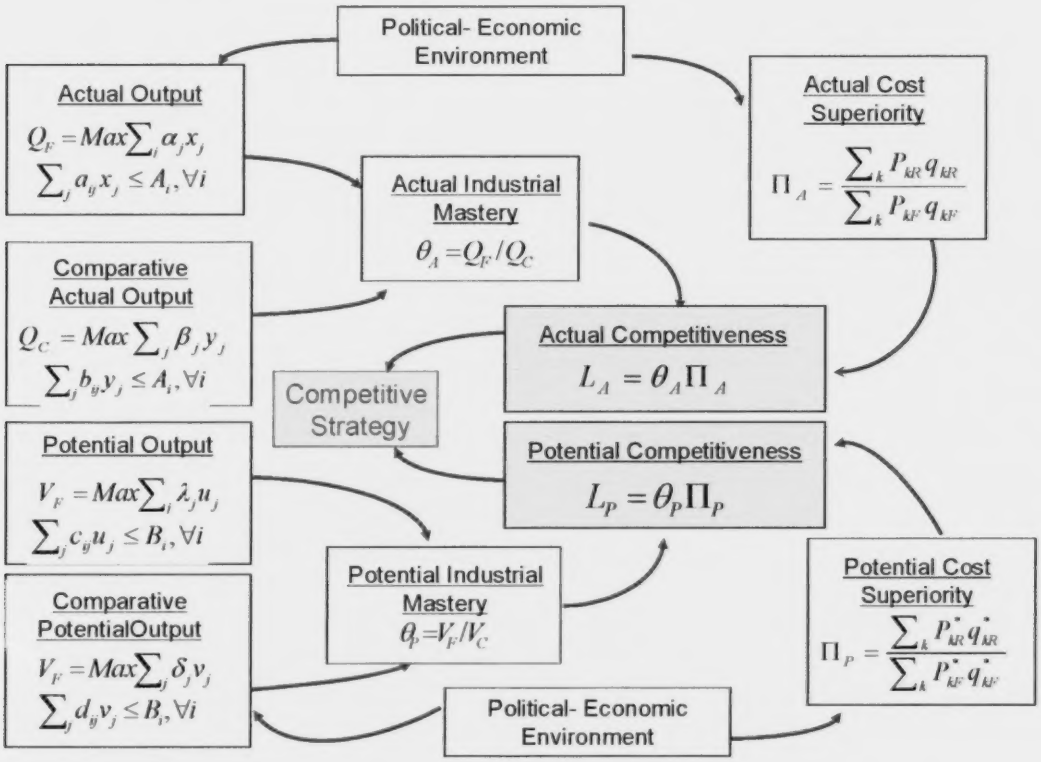
Political- Economic Environment
Actual Output
$Q_F = Max \sum_j \alpha_j x_j$
$\sum_j a_{ij} x_j \le A_i, \forall i$
Actual Cost Superiority
$\Pi_A = \frac{\sum_k P_{kR} q_{kR}}{\sum_k P_{kF} q_{kF}}$
Actual Industrial Mastery
$\theta_A = Q_F / Q_C$
Comparative Actual Output
$Q_C = Max \sum_j \beta_j y_j$
$\sum_j b_{ij} y_j \le A_i, \forall i$
Actual Competitiveness
$L_A = \theta_A \Pi_A$
Competitive Strategy
Potential Output
$V_F = Max \sum_j \lambda_j u_j$
$\sum_j c_{ij} u_j \le B_i, \forall i$
Potential Competitiveness
$L_P = \theta_P \Pi_P$
Potential Industrial Mastery
$\theta_P = V_F / V_C$
Potential Cost Superiority
$\Pi_P = \frac{\sum_k P^*_{kR} q^*_{kR}}{\sum_k P^*_{kF} q^*_{kF}}$
Comparative PotentialOutput
$V_F = Max \sum_j \delta_j v_j$
$\sum_j d_{ij} v_j \le B_i, \forall i$
Political- Economic Environment

Figure 7: The Industrial Competitiveness Model – ICM

First, however, we would like to make some comments on the process of modeling firm competitiveness and the Industrial Competitiveness Model, and ICM henceforth. Comparing Figure 4 (Conceptual Model) and Figure 7 (Formal Model - ICM) reveals that:

- Both the formal model and the conceptual model have exactly the same causal structure, implying in fact a perfect matching between the two. They have the same factors/variables and the way the factors/variables are related to one another remains unchanged in both.
- The formal model – ICM consists of four sub-models and six indices that are related to one another according to the conceptual model. All sub-models are optimization mathematical models and all indices are formulations.
- The formal model – ICM with its two types of competitiveness leads to formulation of competitive strategy according to the nature of the difference between actual and potential competitiveness. This is realized through identifying the strategic state in which the firm finds itself and then formulates the strategy accordingly, as we discussed previously.

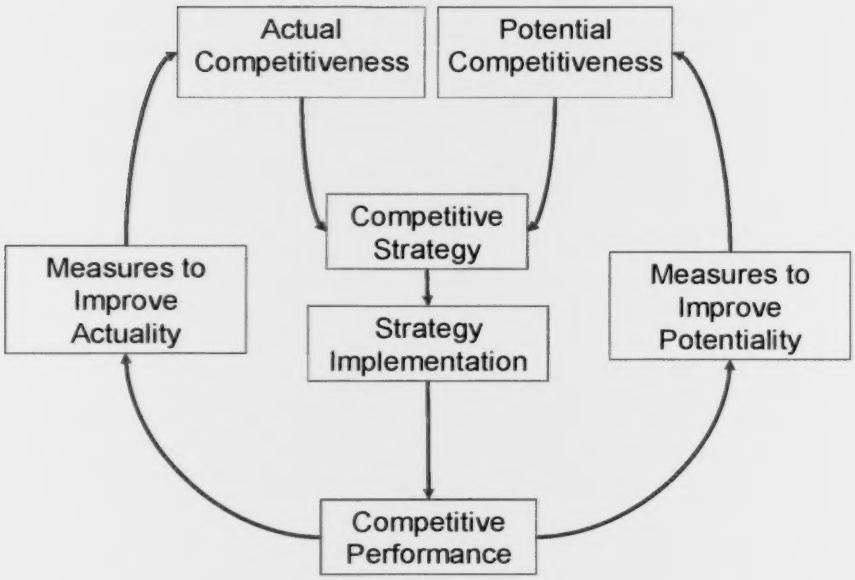

Figure 8: Dynamics of Feedback System for Competitive Strategy Formulation

- Competitive strategies formulated according to the strategic states lead to introducing measures to improve either actual competitiveness or potential competitiveness, or both. This process, as can be seen in Figure 8, is to be repeated in a manner that forms a dynamic feedback system.

- The formal model – ICM implies that there are many parameters that need to be estimated. These model parameters can be divided into two groups: (1) those that are related to the firm (α_j's, a_{ij}'s, λ_j's, c_{ij}'s, P_{kF}'s, P^*_{kF}'s, q_{kF}'s and q^*_{kF}'s) and (2) those that are related to the competitor (β_j's, b_{ij}'s, δ_j's, d_{ij}'s, P_{kR}'s, P^*_{kR}'s, q_{kR}'s and q^*_{kR}'s.) The estimating these parameters alone can generate a lot of information about the firm and the competitor and can be even more useful when they are put into use through the formal model.
- The ICM explained above gives the competitiveness of a firm against a chosen competitor in a given market of interest. Of course, a firm might have more than one competitor in a market and be active in more than one market. In such cases, we repeatedly use the ICM, as many competitors as we need to survey, to analyze the competitiveness of our firm. The way this analysis is made is explained in the next section.

4. ICM AND SOME STRATEGIC DECISION AREAS

We shall present two set of strategic decision areas where the ICM is an instrument. The first group includes those that have already been used in practice, and the second group refers to those that can be of potential use.

Real Life Applications of The Industrial Competitiveness Model

SWOT Analysis: The SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis as a conceptual framework plays an important role in strategy formulation. Although different tools are employed for SWOT Analysis (Porter 1991), the basic objective is to identify the comparative advantages and disadvantages of a firm against its current and potential competitors. From this perspective, the ICM is a most natural tool for analyzing the competitive position of a firm because:

- The ICM provides information as to where the firm stands against its rivals in term of competitiveness levels; actual and potential,
- The ICM points out the comparative advantages and disadvantages with respect to technological parameters, input costs and usage rates, managerial proficiency and effectiveness,

- The ICM, moreover, guides strategic decisions as a function of the identified eight strategic states (Figure 5) in which a firm might find itself.

There are two real life applications of the ICM from the perspective of SWOT Analysis: (1) Pragmatic Application – using a simplified version of the ICM, and (2) Full Application – using complete version of the ICM. The pragmatic application was done for the Industrial Development Bank of Turkey in the case of 30 local firms in three industries; textiles, food processing, and glass manufacturing. The results of this pragmatic application are reported in Oral and Ozkan (1986). The full application of the ICM, on the hand, was executed in two divisions of The Turkish Glass Works, Inc. Some details of this full application can be found in Oral (1993).

Competitive Strategic Decision Support System: Business intelligence is an important issue for competitive strategy formulation, for it shapes the perception of managers regarding the forces and characteristics of rivalry in their environment in relation to their firm. It becomes even more crucial and essential in the case of competitive strategy formulation because managers need to know about their competitors and market conditions in order to make sound and effective decisions. For this purpose they need to have a system or framework for business intelligence gathering and processing activities. We may call such a system Competitive Strategic Decision Support System (CSDSS). A CSDDS, therefore, should support managers to collect and process business intelligence data, and also should include a model basis to guide them in decision making.

The ICM has these features to design a CSDSS and it has been used for this purpose in practice. The study done for the Turkish Glass Works, Inc. to design and implement a CSDDS was based on the ICM. Figure 9 depicts the general features of the CSDDS built.

As can be observed from Figure 9, there are three parts of the developed SCDSS structure: (1) competitiveness data base, (2) competitiveness model base, and (3) dialogue management system. Competitiveness data base is for collecting, storing, and processing data basically required by the ICM. Competitiveness model base includes all the sub-models and indices of the ICM, plus some forecasting models to estimate the future values of the ICM parameters (See Oral, 1985). Dialogue management system established the functionality links between model base, data base, and mental models of managers through "scenario formulation" capability, thus allowing the users to analyze the consequences of different assumptions and/or measures on the competitiveness level of the firm.

One important question about the usability of the ICM is that whether it is possible to obtain the data and information required for competitive strategy formulation. The data requirements of the ICM are rather demanding, especially data about the competitors, but not impossible to obtain them. In the case of the Turkish Glass Works, Inc., the sources of information included the annual reports of competitors, industry studies conducted by

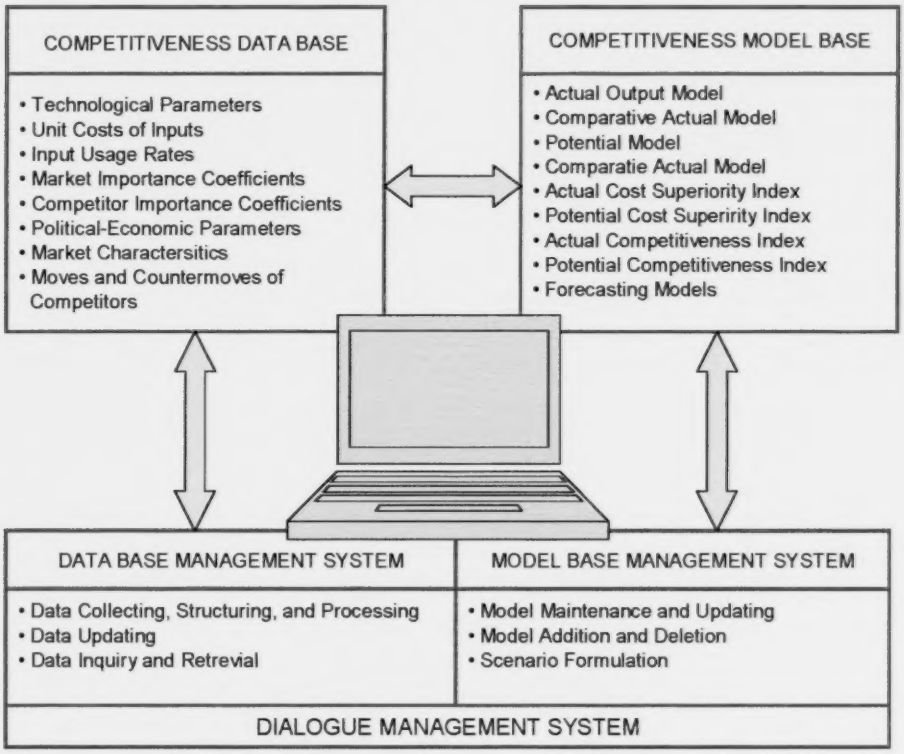
COMPETITIVENESS DATA BASE
• Technological Parameters
• Unit Costs of Inputs
• Input Usage Rates
• Market Importance Coefficients
• Competitor Importance Coefficients
• Political-Economic Parameters
• Market Charactersitics
• Moves and Countermoves of Competitors
COMPETITIVENESS MODEL BASE
• Actual Output Model
• Comparative Actual Model
• Potential Model
• Comparatie Actual Model
• Actual Cost Superiority Index
• Potential Cost Superirity Index
• Actual Competitiveness Index
• Potential Competitiveness Index
• Forecasting Models
DATA BASE MANAGEMENT SYSTEM
• Data Collecting, Structuring, and Processing
• Data Updating
• Data Inquiry and Retrevial
MODEL BASE MANAGEMENT SYSTEM
• Model Maintenance and Updating
• Model Addition and Deletion
• Scenario Formulation
DIALOGUE MANAGEMENT SYSTEM

Figure 9: The Architecture of CSDSS

consulting firms, reports and statistics published by industry associations (European Glass Manufacturers Association), proceedings of industry conferences, government publications, publications of the Chambers of Commerce and Chamber of Industry, companies supplying machinery and equipment, companies supplying technical know-how, major suppliers and customers, reports and statistics published by international organization, and visits made or received by the company people. The reader is referred to Oral (1987) for the details of the competitive intelligence sources and how the responsibilities are shared by different departments and functions at the Turkish Glass Works, Inc.

The two areas discussed above are only just two examples of several applications of the ICM in practice. The other areas of its real-life application include cost-reduction

management through cost superiority indices, technological investments through actual and potential output sub-models, and strategic planning through the difference between actual and potential competitiveness levels. Now we shall return to the other potential uses of the ICM and again we shall give only two areas of possible applications: marketing and technology selection.

Some Potential Uses of The Industrial Competitiveness Model

Estimation of Likely Market Shares: If we assume that the market share of a firm is a function of its competitiveness level, then one must be able to estimate the likely market share of the firm using the industrial competitiveness model. Let us define I_{PR} as the *potential* competitiveness level of the firm against Competitor *R (R=1,2,3,,...,N)* in the market of interest to the firm. Then the likely market share M_S^* of Competitor *S* can be estimated from

$$M_S^* = \frac{I_{PR}^{-1}}{1 + \sum_R I_{PR}^{-1}} \tag{7}$$

Note that here the competitiveness level of the firm against itself is equal to 1, thus the value 1 in the denominator of the expression in (7). Let us assume that we have used the industrial competitiveness model to estimate the potential competitiveness of our firm against Competitor 1, 2, 3, 4, and 5 and found the following results: $I_{P1} = 1.22$, $I_{P2} = 1.51$, $I_{P3} = 0.72$, $I_{P4} = 0.93$, $I_{P5} = 1.01$, and $I_{PF} = 1.00$ (the firm against itself). The most competitive competitor is Competitor 2, because the firm has the lowest competitiveness value against that competitor. Therefore, Competitor 2, being the strongest in the market, should expect to have the highest market share. Using the formula in (7) we obtain the likely market shares of the companies in the market as follows: $M_1^* = 0.19$, $M_2^* = 0.24$, $M_3^* = 0.11$, $M_4^* = 0.15$, and $M_5^* = 0.16$, and $M_F^* = 0.16$ or 19%, 24%, 11%, 15%, 16% and 16%, respectively. Indeed, Competitor 2 has the highest likely market share; that is, 24%.

The likely market share estimates are useful for at least two purposes: (1) they can be used as market share targets for the companies in the market, and (2) they can serve as performance indicators when compared with the actual markets shares. Suppose that the likely market share of the firm is M_F^*, then the market share objective of the firm could be

set to be at least M_F^*. Let M_F be the actual market share. Then the ratio $M_E = M_F / M_F^*$ indicates the competitive/marketing effectiveness of the firm. The value $M_E > 1$ suggests that the firm is doing better than what is expected from it; otherwise the firm is below the level it is supposed to be in terms of competitive/marketing effectiveness.

Marketing Strategy: Market - Oriented versus Competitor - Oriented Analysis: A firm is usually active in more than one market against more than one competitor in markets. In such cases we need to expand the use of the industrial competitiveness model. We can perform three types of competitiveness analysis: (1) Market-oriented, (2) competitor-oriented, and (3) global – both market and competitor-oriented.

Market-oriented analysis requires a repeated use of the ICM for each competitor in each market. Suppose this is done and let L_{MC} be the competitiveness level (be actual or potential) of the firm against Competitor C in Market M. To see the competitiveness of the firm in Market M, for instance, one can define

$$L_M = \sum \sigma_c L_{MC}$$

as the competitive position of the firm when all competitors are considered in Market M, where σ_c is the "importance" of Competitor C. Finding all L_M's permits to rank the markets according to the firm's competitiveness levels in these market, which is an essential piece of information for marketing strategy.

Competitor-oriented strategy, on the other hand, is most useful if the firm is facing the same competitor or competitors in all or almost in all markets. In this case, we define

$$L_C = \sum \mu_M L_{MC}$$

as the competitiveness level of the firm against Competitor C in all markets considered, where μ_M is the importance of Market M to the firm. Again, after estimating all L_Cs, we can rank the competitors according to the competitiveness levels of the firm and devise marketing strategies accordingly.

Performing both market-oriented and competitor-oriented analysis is necessary to position the firm against all competitors in all markets, thus giving a global or general picture of the firm's competitiveness.

Technology Selection: Technology selection is a strategic issue and covers more than one planning period. The ICM has been discussed for single period only. For strategic decisions, however, the ICM needs to be used for several periods to see how the firm's competitiveness behaves in the long run. Suppose that we have opted for global competitiveness analysis in the sense we discussed above and we would like to estimate the impact of certain technology alternatives on the firm's competitiveness level. Any technology alternative will make changes in the values of λ_j's, c_g's, and q^*_{kF}'s first and then in $L_P = \theta_P \pi_P$.

Here we need to introduce a "time" dimension to our formulations and adjust the notations accordingly. Let $L_\psi(t)$ be the potential competitiveness level of the firm at time *t* if Technology ψ is selected, $\psi = 1, 2, 3, \ldots, \Psi$. Then we can estimate the "Net Present Competitiveness" of the firm due to Technology ψ from

$$L_\psi = \int_0^T L_\psi(t) e^{-rt} dt \qquad (8)$$

where *r* is an appropriate discount rate. Using the expression in (8), we can estimate the "Net Present Competitiveness" of each technology alternative and select the one that gives the maximum value. The use of (8) however requires the forecasts for λ_j's, c_g's, and q^*_{kF}'s in the sub-models and indices. This feature of (8) in fact provides a good framework for the firm as to which kinds of forecast are needed for competitive strategy formulation. The reader is referred to Oral (1985) for some details of the way the ICM can be used for forecasting competitiveness.

The other potential uses of the ICM could be the areas of R&D planning through actual output sub-model and actual cost superiority index, performance management through the two indices of mastery (actual versus potential) and the two indices of competitiveness (actual versus potential).

5. CONCLUDING REMARKS

This paper is, in a sense, an allegorical writing based on the articles of Oral (1985, 1986, 1987, 1993) and his colleagues (Oral and Ozkan, 1986; Oral and Reisman, 1988, Oral and Dominique, 1989.) Yet, there are so many issues that are still left untouched due to the space limitation normally enforced in an academic article of this kind. One area of

particular interest is that how frameworks and models become complementary to one another for a better understanding of firm competition. For instance, the frameworks suggested by Porter (1980 and1985); namely, the five-force competitive analysis and value chain framework, are useful tools for positioning a firm in its competitive environment vis-á-vis others. The frameworks suggested in the literature could have been even more useful and operational tools if there were formal models based directly on these frameworks. Or, alternatively, it might be interesting to show how well the known frameworks are reflected in some formal models.

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